PREDICTION OF SUCCESS IN FIRST YEAR ENGINEERING

ARTHUR FITZPATRICK

SYNOPSIS

In Canada, as in other countries, the training of an adequate number of engineers for the requirements of our technical society has been an acute problem. This project was undertaken, through the medium of the records which were available at the University of Alberta, in order to evaluate the effectiveness of present selection devices.

In this study, a general review has been made of the results of other investigators in the problem of success during the first years of engineering; more specifically, this investigation is concerned with the performance of the 1954-1955 freshman engineering class at the University of Alberta in Edmonton.

This writer has discovered no significant differences between the overall first year marks of students who had a high school background in elementary calculus and in plane trigonometry under the earlier school system and those who had taken algebra only in the more general Mathematics 30 course given during the 1953-1954 school term.

Significant differences were found between the first year marks of the freshman rural student and those of the urban student. In this sample, it is possible that this result is related to the fact that significantly lower percentages of students attended from the rural areas.

Conversely, the rural students who attended city high schools before going to university received significantly lower marks both at the high school level and at

the university level. These students also obtained lower scores on the American Council on Education Psychological Examination.

Using several control groups, a median correlation coefficient of 0.60 was found between high school averages and first year marks in engineering. This parallels the results found by other investigators. However, when the average Grade XII mathematics, chemistry, and physics marks were used as predictors, this index was increased to approximately 0.70. Other writers have shown that in American universities the validity index can be raised to about 0.80 when psychological tests are also included with high school averages in a multiple correlation against first year marks.

The overall results of this study indicate that high school departmental examination results correlate highly with first year engineering marks. However, it is possible that increased numbers of potential engineering students could be obtained by abolishing the presently required senior matriculation and the Grade XII 60% average. Improved selection may then be accomplished by using the Grade XII mathematics-science average or an achievement entrance examination. Any such composite measure should be established on the basis of later validation research. The aim of this study has been to indicate the design for such a research project.

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INTRODUCTION

This study arises from the author's interest in the field of prediction by means of psychological tests, especially in the prediction of success among engineers and technicians. This writer finally decided that psychometric research on a large and homogenous group such as engineering freshmen offered many advantages over comparable research on smaller technical groups which occur in industry, and where the criterion for success was sometimes indeterminate.

This writer unfortunately did not have time in a study of this sort to carry out a broad type of testing program appropriate towards the solution of this problem. In addition, the author did not reside in Edmonton, and would have found it inconvenient to remain there for an extended period in order to give complete battery of tests to the incoming engineering freshmen. However, the records maintained by the university provided ready data for a study in prediction and so it was undertaken by the writer.

Further, it has long been felt by some students of education that the present selection of engineering freshmen by means of Grade Xll averages might be improved upon. The need to do this becomes especially pressing when one considers that, in the 1953-1954 freshman engineering class, only 45.5% of the new students in the class passed all of the first year courses.

In view of the fact that engineering personnel are at a premium and that other countries, notably Russia, are producing engineering graduates at a higher rate and perhaps of higher calibre (on the average) than Canada, the situation is serious. It was not known precisely why a high percentage of students were failing (30.0% of the new students received Category II or Category IV from the first year committee).

It was thought that a comprehensive study of high school marks might thus shed some light on this problem of improving selection. A technique of multiple correlation, for example, might lead to a more accurate composite predictor than a Grade XII average. There were also the results of psychological tests given at the beginning of the year that could be incorporated into the composite, perhaps further enhancing the predictive value of such a combined score.

How much, then, can the present selective process be improved upon, while permitting as many as possible to enter first year engineering? This was the general problem that this study attempted to deal with, at least in part.

It seemed likely that the academic records from high school, the American Council on Education Psychological Examination, the Iowa Silent Reading Test, and the Iowa Placement Examination (English Training) would provide a comprehensive enough group of predictors for an initial study.

In addition, with the exception of English Training, the present tests were given as a matter of routine from year to year. Other tests could be added as the need arose, and, as indicated from this study, and perhaps they could be incorporated as predictors at a later date. This procedure would result in a fairly close approximation of a best composite predictor. Thus, if another predictor were used, a multiple correlation for this new test and the weighted total for other variables, as indicated by the present study, could be made.

Since Mathematics 31 was introduced in high school in 1955 and has become a requisite course for first year Engineering students, it is very likely that this procedure of revalidating would become necessary. The effect of having taken calculus and plane trigonometry on later university marks was also thought of some importance in the above connection, because this course was used as a springboard by many critics of the present educational system to point out the dangers of watering down the high school program.

In view of the above considerations, this study was undertaken. The scope of the study was limited by the nature of the records available. On the other hand, wherever a variable was obtainable from the records, a study was made of its effect on success. This procedure mostly produced failures, but there were several findings that vindicated the technique.

SURVEY OF THE LITERATURE

A great deal of research has been done during the past thirty years on prediction of academic success in engineering schools and colleges. In many cases,asingle criterion was used, but in later years there has been a tendency to combine several measures into a composite score.

Because of the indeterminate nature of both predictor and criterion, it was unlikely that any single measure would ever suffice for the determination of success in either the freshman or the more advanced years. It would thus be well to proceed carefully and, before an attempt was made to arrive at a best predictor for any one year, it was thought wise to look over the results obtained by past experimenters. An analysis should be undertaken with an eye to what variable will seem most important in future years. A predictor useful in foretelling success in the first years but conflicting with later achievement would not serve the purpose; where two measures predicted equally well in first years, it would be important to retain the one with the greatest long-range validity.

Let us therefore consider the tests individually, as has been done during the early stages of research, and consider each type of predictor on the basis of its own merits.

These predictors are dealt with in approximately the order of their past record of predictive merit. It is

likely that this order occurs because of the relative similarity of the type of test with the criterion in each case. However, it is also likely that the final criterion of job performance would not be related to these measures in the same order. Indeed, factors such as personality and interest would be expected to be far more important here.

High School Achievement

Generally speaking, high school marks have proven to be the best predictor of success in first year engineering. This fact has been borne out (61) by numerous investigators, both in the prediction of engineering grades, and in the prediction of grades in other university courses. The range of correlations reported (36) is from .45 to .75 with 0.60 being approximately the most commonly reported (20) figure. Frederickson and Schrader report (32) this validity index both with veteran and non-veteran engineering students, and that in both cases, high school performance was a better predictor than the A.C.E. Psychological Examination.

Laycock and Hutcheon, in a study at the University of Saskatchewan on engineering students, found (46) that average Grade XII marks were by far the best predictor out of a number of variables used, and they obtained a zero-order correlation of 0.61. This was also the figure obtained (20) (22) (74) by other investigators.

Nelson, at the University of Alberta, obtained (57) a correlation of 0.66 against first year marks, using the average of Algebra, Trigonometry, and two Science courses from Grade XII (Alberta) as predictors. Again, no other

predictor was of more value than the high school marks.

Stuit, Dickson, and Jordan report (66) on the other hand that in their survey of the literature, the average correlation was 0.55 for American engineering colleges, with measures above 0.60 rarely being found. This may indicate that high school marks have more predictive value in Canada than in the United States.

Since high school work and university work bear a close resemblance, it is natural that relationships such as those given should exist. This fact is capitalized upon by most universities requiring a certain standard of performance in their graduates. Indeed, it is likely that all accredited universities demand some standard or level of performance in pre-university academic training. On the other hand, there exists a general feeling that students who perform well in high school and in university do not necessarily perform in their later work at the same level. There are other factors, therefore, which contribute to later success, and these should not be ignored.

There is also the unreliability of the high school mark assigned to students, especially in the non-Departmental type of examination, where the marking is done by individual teachers. There are more reliable measures of scholastic aptitude, which, while they may not have the high validity of past scholastic records, would nevertheless have something to contribute. For example, Cohen found (20) that scores in a battery of tests, including the Iowa Silent Reading Test, the Yale University

realities and of such items that the high school years.

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There is also the possibility of the high school work assigned to students, especially in the more-theoretical type of examination, where the student is one of individual interest. There are more [illegible] designed to [illegible] which [illegible] liability of that particular method, would [illegible] according to individuals. But [illegible] (27) [illegible]

Department of Personnel Study Test II, and the American Council on Education Co-operative General Achievement Tests in Mathematics, Physics, Chemistry, and Reading Comprehension, when combined in a multiple regression equation with high school averages in Mathematics and Science, correlated .71 with first year Engineering marks.

<u>Achievement Tests</u>

It is common practice in the selection of potential university students to have some level of performance demanded from the selected candidates, as measured by an achievement test made up by the department concerned. Especially where small groups are concerned, the essay type of test has been widely used. In general, the results of this type of testing have not been published. Indeed, in many cases, the test has been made up for the occasion and may not have been used again.

As would be expected, the reported correlations between standardized achievement tests and first year marks for engineers ranged slightly below that of high school marks. Correlations, reported between mathematics (20) tests and engineering grades average about .55, while physics, chemistry, and science achievement tests correlate about .45 to .50. English tests reputedly (47) correlate .40 to .45 with engineering grades. Jones found (40) that of the Co-operative Series, the mathematics, physics, and chemistry tests were the best predictors of first year marks in an engineering college. The manual reports (21)

a correlation of .42 between an early form of the Co-operative mathematics test and marks for first year physical science students. In this same study, the physical science test had a validity of .28. The Educational Testing Service have accumulated (47) validity figures for the Co-operative Mathematics Test (r=.54), and the Co-operative Intermediate Algebra Test (r=.63).

In most engineering schools, graduation from high school is required. However, in the technical school, this is not always the case, and without a common available mark (such as Grade XII average) to use as a predictor, it is possible that achievement tests would be of more use in the technical school than in an engineering college.

In unpublished studies made (76) (77) by Brown, Bowering, and Young at the Provincial Institute of Technology and Art in Calgary, it was found that a two-hour mathematics achievement test correlated .78 (N=67) with first year mathematics scores in 1949, and 0.69 in 1950 (N=111). This test had a reliability of 0.68 and correlated with the Otis gamma 0.56. The utility of such tests would depend upon the ingenuity of the writers, and the institutions using them.

However, a test that had been proven of great value in other institutions, and then had been validated and found useful for the institution in question, would likely

be a better instrument for selection than a test with the same validity but which had been conceived and used for only the one institution.

Scholastic Aptitude Tests.

Special college entrance examinations have been devised over the years, with the American Council on Education Psychological Examination as one of the better known of these. This test is usually referred to as the A.C.E.

Estes found (28) that, while the correlation of the Q score of the A.C.E. with engineering grades in analytical geometry was .33, the L score correlated .15. Shanner and Kuder found (62) a total score correlation of .48 with marks in the physical sciences.

While Laycock and Hutcheon found (46) only a .34 correlation with first year engineering marks, and .50 with first year arts and science marks, Frederickson and Schrader found (32) that the A.C.E. gave a correlation of .47 to .57 with the first year marks in engineering. Schmitz found (61) a correlation of 0.58, and Votau reported (74) a correlation of 0.61 with freshman engineering grades against the A.C.E.

Using the Yale Scholastic Aptitude test as a predictor of success in a college of engineering, Vaughn found (72) the Mathematics Aptitude and Quantitative Reasoning sub-tests to be the best with correlations of .51 and .50. Spatial Visualization was third (r=.39). Verbal Comprehension, Mechanical Ingenuity, and

Artificial Language sub-tests were lowest at .31 and .36, respectively. The overall validity of the battery varied from .50 to .66 in the 1,800 engineers tested.

Layton has resummarized (41) the work of Cowles, Cynamon, Lord, and Schrader, who were reported by Johnson to have found that the College Entrance Examination Board composite of both the Scholastic Aptitude Test, Mathematics Section, and the Comprehensive Mathematics Achievement Test, correlated as high as 0.68 against engineering grades in a regression equation also including high school marks.

It is difficult to classify into rigid categories the various tests used as predictors of academic success. In the following section a review has been made of the results obtained when using tests similar to the academic aptitude tests such as the Physical Science Aptitude Test which was designed to predict achievement in the sciences.

<u>Specific Aptitude Tests</u>:

There have been numerous studies that have segregated potential abilities or aptitudes into definite categories. Some of these aptitudes have subsequently proven to be valid predictors of success in engineering schools. Notable among the various aptitude tests related to achievement in the first years of science are those of mechanical aptitude, spatial aptitude, mathematical aptitude, and the science aptitudes. Insofar as the test specifically measures one of these aptitudes, the predictive value has been shown to decrease in comparison with either the more general type of test or the scholastic aptitude test. Combinations of the

scores from several tests, however, have yielded much higher validity coefficients than previously obtained. In order to simplify a study of this type of predictor the most important aptitudes have been dealt with one at a time, in the order of their proven relative merit.

Science Aptitude

The "science aptitude" tests have been developed not so much in the interests of the examination of a new and separate aptitude, as distinguished by its uniqueness, but because there has been interest in a special type of test which might be useful in the prediction of engineering grades. The utility of these tests, therefore, has been in their ability to predict success in the study of the sciences. The content of the better predictors is sometimes similar to that of the achievement test, and it is not always easy to classify them as either an achievement or an aptitude test.

According to Vaughn, the members of the Society for the Promotion of Engineering Education, in conjunction with the Educational Testing Service, are constructing and validating (73) the first form of an engineering aptitude test for high school students. Results for this test may be seen under Mathematics Aptitude Tests in the present study.

While Harrison and Jackson found (37) that the Engineering and Physical Science Aptitude Test was not discriminative enough in the selection of graduate mechanical engineers in industry, this test has been proven of great use in prediction of success in first year engineering. A correlation as high as .73 has been reported (54), using the Engineering and Physical Science Aptitude Test total scores against first year marks. The sub-test on mathematics was the best and correlated 0.71 against first year mathematics scores. In this same study, there was a low (r=.35) correlation of this test with first year drafting scores. Perhaps a test for another aptitude, space relations, used in conjunction with the Engineering and Physical Science Aptitude examination would increase the predictive value of this test.

It is interesting to note in passing that the least valid sub-tests reported in the manual so far as first year marks are concerned, are Mechanical Comprehension (r=.49) and Arithmetic Reasoning (r=.52), which indicates the uniformly high validity of the sub-tests, in comparison to other tests.

In another study reported in the manual, validity coefficients of .58 in the first semester to .26 in the eighth semester were obtained (54). In an eight-semester course, the cumulative average validity, using all five sub-tests, was 0.48. Treumann and Sullivan found (71) a correlation of 0.53 for the Engineering

and Physical Science Aptitude Test and first year Engineering grades. Shanner and Kuder report (62) a validity of .65 at the University of Chicago, using first year physical science marks as a criterion.

Nelson, at the University of Alberta, found (57) that the Iowa Physical Science Aptitude Examination correlated 0.55 with first year Engineering marks, and this was the best psychological test in his battery. The manual reports (45) correlation for the four sub-tests to be .56 to .62 against average first year mathematics, chemistry, and physics marks. This test is made up of many computational items and the most valid items have been used in constructing the Engineering and Physical Science Aptitudes Test.

Lord and Cowles found (49) that, in using the Pre-Engineering Inventory in twelve Engineering schools, the sub-tests General Mathematical Ability (median r=.58) and Ability to Comprehend Scientific Material (median r=.50), and Technical Verbal Ability (median r=.48) were the best, with the median coefficient of correlation with first year success for the twelve schools being given.

Moore found (55) correlation coefficients of .68 (N=260) and .75 (N=57), using the Pre-Engineering Inventory and first semester marks. It is likely that this test would have a high correlation with high school marks, perhaps more than the science aptitude

tests previously mentioned.

While Zyve found (79) a very high validity coefficient using his test, it is thought by many writers that his correlation of 0.74 was most certainly spurious. This test has not been found to have high validity (above .4) in later studies. This writer feels, that this is the poorest predictor of the four mentioned science aptitude tests.

Mathematics Aptitudes

It is curious to note that Mandel and Adams found (50) a mathematical formulation test which correlated .59 with salary level in an aircraft factory. It is also reported (47) by Laycock that, in a study of those who dropped out of university after the first year, there was the feeling among the students that the study of mathematics had been of greatest help in their later employment. Probably dependent upon the proportion of mathematics taught during first year, mathematics "aptitude" tests have proven very useful as predictors. In some cases, the mathematics "aptitude" test has proven of greater value than the science "aptitude" type of test mentioned previously.

Lord and Cowles found (49) that the Educational Testing Service Pre-Engineering Inventory mathematics sub-test had a median correlation of .58 with first

year marks for twelve engineering colleges. These figures were very close to those which they obtained using the College Entrance Examination Board Mathematical Tests. The seven Educational Testing Service Pre-Engineering Inventory sub-tests, and eight-hour battery had a median correlation of from .35 to .58 with first year success for the twelve engineering colleges involved.

In 1931, Feder and Adler, in a study of engineering students at the State University of Iowa, found (30) coefficients ranging from .57 to .72, using the Iowa Silent Reading Test, the Iowa High School Content Test, and the Iowa Placement Series: English Training and Mathematics Aptitude. Multiple correlations using all the tests against first semester and first year achievement was .74 and .71 respectively.

Nelson, in his study of University of Alberta engineering freshmen, found (57) that the Iowa Mathematics Aptitude Test correlated .37 with Christmas marks and .41 with final marks.

<u>Space Relations Tests</u>.

During the first phase of validation of tests, perhaps during 1930-1940, the space relation and the mechanical comprehension type of test was used extensively in attempts to predict success in freshman engineers. Later, studies were more concerned with tests such as the achievement and the scholastic aptitude examinations.

Possibly the best known of the space relations tests is the Minnesota Paper Form Board, a two-dimensional test of about the right level of difficulty for engineering students. It has shown correlations of .22 and .42 with first year success, and in addition revealed (68:304) (78) correlations of .26 with first year Physics marks and of .43 with four-year grades. The Form Relations Tests by the National Institute of Industrial Psychology of Great Britain has been shown (46) by Laycock and Hutcheon to have .25 validity in first year marks with Saskatchewan engineering freshmen.

This writer favors the Differential Aptitude Test, "Space Relations" as a test having high face validity insofar as all the drawings are dimetric sketches in relation to an orthographic pattern. While this test has shown (12) a correlation of only .36 with Grade X geometry marks, it is thought the relationship could be higher in first year university, with this type of test, providing the time limits were such as to obtain maximum utility, such as outlined (10) by Ayers. The manual shows (12) engineering students to be outstanding (81%ile) in this aptitude in contrast with other university groups, which range from the 57%ile to the 72%ile, using Grade XII norms. Perhaps the Vocational Guidance Centre Object Visualization Indicator could be added to the D.A.T. space relations tests to give a more comprehensive type of measure, if a more sophisticated test could not be found. A similar three-dimensional

principle is involved in the Mitchell Drawing Aptitude Test, but again, this writer feels that the level is not high enough for engineering applicants.

Perhaps such a test is the one reported (25) in Cronbach and again (11) by Bennett and Cruikshank, called the Mann Dynacube and the Mann Staticube, reputedly correlated as high as .63 with descriptive geometry marks in 1933. This writer, after many attempts, has not been able to secure a copy of this test; perhaps the test was not found worthy of printing. Stuit found (65) a cube visualization test to be a good predictor of first year physics marks.

There is undoubtedly a reasonably high long range validity intrinsic to the space relation type of test. The Survey of Space Relations Test, for example, shows (19) a correlation of .54, with supervisor's judgment of draftsmen. Again, Mandel and Adams found (50) a correlation of .40 between a test for spatial discrimination and salary in a recent study. Read reviewed (60) the work of Holliday who found that the space relations type of test was the best in selecting engineering apprentices in industry.

There are numerous other spatial tests with correlations ranging from .10 to .35 with first year success. It is interesting to note, however, that some of the manual tests show promise as predictors. The Wiggly Blocks test has been known to have (25:214) a

correlation of .30 with descriptive geometry, and the authors of the Crawford Tridimensional Structure Visualization Test report (11) a correlation of .91 between this five-minute manual test and high school teachers' ratings on 39 boys' drafting insight.

Brush administered (68:232) the Minnesota Mechanical Assembly Test to 104 engineering freshmen and found correlations of .28 and .27, with first year and with all four year marks respectively. However, it was felt that, while the results were reliable, the extra trouble of administration was not warranted by the increase in predictive value.

Usually, the correlations in using such tests are low. Young reports (76) rank-order correlations of -.076 with 97 technical drafting students' marks and The Star (Mirror) Test and .27 using 85 students' marks against the Purdue Peg Board. He also found that, while the Wiggly Blocks Test correlated .10 with drafting (N=97), he obtained a correlation of .40 with this test and shop marks using the same group. Using the Tweezer Dexterity Test, he obtained no correlation.

Tests combining a high degree of visualization and comprehension of principles and relationships underlying the operation of mechanical devices give the best prediction. Unfortunately, there are too few of these that are easily administered to groups. However, the mechanical comprehension test necessitates an understanding of principles, and it is thought that a

reasonable amount of visualization is required as well, especially as indicated (15) by factor analysis of some of these tests.

Mechanical Aptitude

Of all the paper and pencil mechanical aptitude tests, the Bennett Mechanical Comprehension Test, Form CC, had proven the best. This is to be expected, since the test was primarily constructed to test engineers at the freshman level.

The manual and Owens report (15) (59) validity coefficients ranging from .16 for the prediction of English marks to .49 in the prediction of Theoretical and Applied Mechanics marks with engineering seniors. It appears that while the science and mathematical "aptitude" tests would be useful in the prediction of pure theory courses, here would be a valuable addition for prediction of the applied science courses.

Halliday, Fletcher and Cohen report (39) a correlation of .43 with the first year drawing marks. Read found (60) the test also useful in selection of engineers on the graduate level for a large electrical manufacturing company.

There are similar tests of mechanical aptitude developed by Bennett and others, but none of these shows the initial or the long range validity of Form CC.

In his earlier test, Bennett found (14) the best correlations with heterogeneous groups, such as naval aviation cadets' success in flight training. He also

found a biserial correlation of .61 with supervisors' ratings of sales and service engineers, and despite the simplicity of the problems, Bennett obtained correlations in the order of .40 to .47 for prediction of first year engineering marks. Items from this test are incorporated in the Engineering and Physical Science Aptitude Test. Form AA is an earlier and easier form of BB, and shows (13) high validity (r=.64) against supervisors' ratings of tool operator trainees' performance after three months.

The manual also reports this test as a better predictor (r=.52, .55) than the Otis or the Minnesota Paper Form Board in ratings of 208 foremen. Physics grades seem to be correlated highly with this test (r=.52).

A related test is the Differential Aptitude Mechanical Reasoning Test, built upon the experience of Forms AA and BB of the Bennett. Many of the items are taken from the Bennett tests, but again the difficulty is not great enough for engineering applicants. Perhaps this test would be of use in selection at the technical school level. While university engineering students (12) score highest (82%ile), it is likely that there is little discriminative value at the college entrance level, since pre-medical students score in the 77%ile. Again, this test correlates with physics scores (r=.47), and would probably be even a better predictor of applied

mechanics. Tests similar in nature, such as the Cox Mechanical Aptitude Test, have similar reported (11) validity coefficient of .41, .42, .40 and .39 against first year engineering grades.

The MacQuarrie Test of Mechanical Ability has a reported (11) validity of .44 against engineering drawing grades, and .48 against average grades. Even the Stenquist Mechanical Aptitude, Form II, has shown (38) reasonable prediction (r = .43) of engineering grades, despite the fact that it is more an achievement than an aptitude test. Young obtained (76) a correlation coefficient of .30 between shop marks and the Science Research Associates Mechanical Aptitudes sub-test Mechanical Knowledge (N=113) in his study of technical students.

The mechanical aptitude test, in contrast to the mechanical knowledge test, deserves attention on a testing battery, for it measures the ability to comprehend relationships in mechanics.

Miscellaneous Aptitude Tests.

It would be futile, if not impossible, to report on all of the "aptitude" tests which have been validated against first year engineering marks. Of interest, however, are results obtained for those tests used in the present study.

McClanahan and Morgan report (51) a multiple correlation coefficient of .85 against freshman engineering marks,

using high school marks, The Iowa Placement Examination Chemistry Aptitude Test, and the American Council on Education Co-operative English Test. The combination of the chemistry test and the English test were the best predictors.

Feder and Adler found (30) that the Iowa Silent Reading Test, The Iowa High School Content Test, and two parts of the Iowa Placement Examination, the Mathematics Aptitude and English Training, gave coefficients ranging from .57 to .72 in prediction of first semester and first year achievement. The multiple correlation with first year engineering marks was .71.

In a study at the University of Minnesota, Layton found (47) that high school marks (r=.61) the A.C.E. Psychological Examination, The Iowa English Placement score, Bennett Mechanical Comprehension Form CC (r=.35), and the Iowa Placement, Mathematics Aptitude were in the given order valued as predictors in a multiple regression equation. When predicting success in the top ten percent of the class, the English Training scores increased in validity to .65.

Standard Intelligence Tests:

The intelligence test has not proven as useful in selection at the university level as in the grade school. This is due to the natural selective process at work in the weeding out of low intelligence individuals at the pre-university level. Generally speaking, the applicant to an engineering college falls within a fairly narrow

range of intelligence, so that accurate prediction on the basis of intelligence alone is usually impossible.

However, typical correlations between academic success and I.Q. do range from .2 to .5. Young, at the Provincial Institute of Technology and Art, obtained (76) a median rank order correlation of .47 for Theory marks, .45 for Mathematics marks, .51 for Shop, and .54 for Science marks, using the Otis Gamma. The following year, he found (77) indices .37 against Theory, .42 for Mathematics, and .25 for Shop, using larger numbers (N=114). These figures are reasonably high for this type of test, and may be indicative of the hetrogeneous level of intelligence of the students at this institution.

Goodman reports (34) validity coefficient of .08 to .36, using the PMA sub-tests. The number factor had a correlation of only .36 and the spatial factor .18,with first year semester point averages in engineering. Stuit found (68:304) that engineers scored highest on the Spatial and Deduction scales, lowest on the Verbal and Memory scales. Shanner and Kuder give (62) a multiple correlation, using the PMA, sub-tests of .56 against the physical science first year marks.

It is reported (17) by Bernreuter and Goodman that in a study of 170 freshman engineers at Penn State, The Thurstone Primary Mental Ability Test, had a validity coefficient of .51 with first year success in a multiple regression equation of the sub-tests, even though correlation with

drafting was low.

Davidson reviewed (26) the classic work of Jones and Ruck, who found that dull students study somewhat longer hours than superior students. When hours of study were partialed out, intelligence was found to have a correlation coefficient of .69 with grade points of university students.

However, the indices of the intelligence tests are usually lower than these given, and many writers, such as Borow, feel (26) that other factors must be at work in the overall determination of university marks.

<u>Measures of Personality</u>

Because of the failure on the part of achievement and intelligence tests to predict the level of college performance satisfactorily, many investigators have felt that personality must be an important contributing factor. Davidson in a general study including some engineering students at the University of Alberta, found (26) that the poor student did score significantly higher on the hypochondriasis, hysteria, and psychopathic deviate scales of the Minnesota Multiphasic Personality Inventory (N=38). In the same study, she found that the underperformer scored high on the Home Adjustment and the Health Adjustment scales of the Bell Adjustment Inventory.

In a case study, Kirk showed (42) how a pent-up rebellious attitude toward parents had lowered college

performance. Repression of this hostility is undone during the stress of the examination. Kimball found (43) a poor father-son relationship present in under-performers. The loss of control at the university permits the overthrow of the parent, leading to non-performance about which the subject is very self-derogatory. This has been borne out (22) (24) (60) (67) by many investigators.

In an evaluation of the non-intellectual factors contributing to a student's success at university, Morgan found (56) that a) the awareness and concern for the other person; b) a sense of responsibility; c) dominance, persuasiveness, and self-confidence; and d) motivation to achieve, were most important, as measured indirectly by twelve special scales of the Minnesota Multiphasic Personality Inventory and by the Thematic Apperception Test.

While it has been shown that the general adjustment is of great importance in determining marks, the real problem is of accurately measuring this adjustment. For example the Bernreuter Personality Inventory has been shown (68:493) in one study to have zero correlation with achievement. Laycock and Hutcheon, also using the Bernreuter in their study of engineering students, found (46) zero correlations with marks.

McKinney, in using the Thurstone Personality Schedule, and the Kent-Rosanoff Free Association Test, found (52) that the adjusted university student obtained more honor

marks and participated in more activities than the poorly adjusted student. These findings are practically contradicted by Young, Drought and Bergstresser, who were reported by (26) Davidson as having found that an excessive social life lowered marks. Young, in another study, postulates (78) that the intelligent introvert has twice as good a chance of passing as someone lacking these qualities. The stable extrovert was least likely to succeed. This was also the finding (31) of Fitzpatrick in a study involving first year commerce students, using the Guilford-Zimmerman as a predictor. There have been numerous studies, some showing (26) low correlations between personality traits as measured by the tests, and some showing zero correlations with academic success. It is unlikely that the predictive value of these tests is enough to warrant inclusion in a selection battery, where faking of answers could be done. This would also be true for the study-habits tests, where zero to low correlations have been found (26) (33) (75) and yet these tests offer a suitable yardstick upon which the student may evaluate his own strength and weaknesses.

Measures of Interest

Perhaps the most widely used interest test at the college level is the Strong Vocational Interest Test. This test has proven of great value in guiding young people into their most rewarding occupation. It is likely that the interests of college freshmen have crystallized sufficiently to be measured with fair accuracy. With

engineers, for example, the test retest reliability has proven (64) to be .75 in ten years and .76 in nineteen years.

Melville and Fredrickson found (53) correlations of up to .32 (Psychologist), using the Strong VIB, against the difference between actual grades and grades predicted by a multiple regression equation including scores on the College Entrance Examination and a measure of secondary school achievement. Morgan found (56) that of the non-intellectual factors related to high academic achievement of the university level maturity and seriousness of interests were the most important as measured partially by the Interest Maturity scale of the Strong. Achievers had interests in Group V, while non-achievers had interests in Group VIII and Group IX.

Fitzpatrick found (31) that the achiever in first year commerce scored significantly higher than the non-achiever in several scales of the Strong V.I.B.

Altender reports (9) that low scholarship men tended to make higher engineering interest scores than high scholarship men, who tend to have interests more like teachers or C.P.A.'s. She found low (-.28 to .30) but significant correlations for the individual scales. Berdie found (16) a correlation of .13, with engineering honor-point ratios using the Strong V.I.B. engineer scale, and also discovered that a variety of interests had no detrimental effect upon performance. Campbell found (63:521) a validity index of .32 and .185 for the

engineer scale, and .31 for Social Science Teacher, using first year engineering grade-point ratios as a criterion. Holcomb and Laslett report (38) a validity index of .32 between engineering interest and engineering grades.

The test has long range validity, since is was constructed using adult norms, and Read found (60) that it was useful in the selection of graduate engineers for a large manufacturing company.

Strong found (63:118) that while the correlation between interests of engineers in various fields was high (.8), it might not be impossible to segregate the groups by taking the point of reference as engineers in general, for example, instead of men in general. Estes and Horn have shown (29) that this approach is productive.

Long and Perry found (48) that in the final year of engineering, neither the Strong V.I.B. nor the Kuder Preference Record was useful in a battery to predict marks. This was to be expected in view of the select group employed.

Next to the Strong V.I.B., the Kuder Preference Records, Vocational and Personal, are tests of utility in the prediction of academic success. The highest correlations reported (44) in the manual range from .49 for the computational scale to .32 and .29 for the scientific scale with grades in the physical sciences as a criterion. However, the Kuder is probably easier

to falsify, and when the interest tests are used in a selection setting, zero correlations sometimes result.

Laycock and Hutcheon found (46) that the Thurstone Physical Science Interest and Academic Interest scales did correlate .26 and .20 with first year engineering marks.

There is undoubtedly a relationship between the liking of a course and the marks in it. The courses best liked are also the best predictors of general achievement in grade school (58). However, the interest test, like the personality test, will probably remain of most use as an instrument for guidance rather than selection. For selection purposes, perhaps an indirect measure of interest can be obtained from the past performance in various subjects. This measurement is essentially made when the technique of multiple correlation is used.

In summary, it can be said that the best selective devices are probably:

a) High school achievement in which the Grade XII average seems to be universally used.

b) Achievement tests, the best of which are at the Grade XII level, are useful when high school marks are not used.

c) While Scholastic Aptitude tests have been used more than other tests in entrance examinations, their utility is not great in the case of engineering students.

d) Specific aptitude tests, such as the Engineering and Physical Science Aptitude Test, more difficult three-dimensional space relation tests, and the Bennett Mechanical Comprehension Test, Form CC., have in general proven superior to the general scholastic aptitude test or to the intelligence test, in predicting engineering academic success.

e) Despite the fact that the failing student has been shown to have a specific personality, standard personality tests have not consistently been found to have predictive value. Perhaps a new test is required for this purpose.

f) Reports on the validity of interest tests have proven conflicting. At the university entrance age, it is likely that the measurement of interests should remain in a clinical setting.

On the basis of the above, there appear to be many profitable fields of study. A technique in which past marks, engineering aptitude, and a measure of certain specific aspects of the personality, were combined into a composite score, would probably yield the most fruitful results so far as selection was concerned. In the case of guidance of the engineering applicant, it is likely that several standard tests, including the interest tests, will continue to be the most valid tools for the purpose.

III

THE PRESENT STUDY

This study is concerned with the prediction of academic success in first year engineering. A list of the predictor variables used is given here, along with a short description.

Many potential predictors, especially some psychological tests, did not appear on this list. It is likely that if predictors such as those recommended for use under the Survey of the Literature had been used, then the results of this investigation would have been more fruitful. However, the following variables were available at the time of the study, and so they were used.

Information on the experimental group was available from a number of sources. The Student Advisory Services maintained files containing scores on tests which they had given, along with transcripts of high school records. From these records, the following predictor variables scores were taken. These variables are named by the underlined part only in later sections of this study.

Variables available from records in the Student Advisory Services.

#1. American Council on Education, PSYCHOLOGICAL EXAMINATION, 1947 Edition for College Freshmen, Quantitative Score, Q, consists of raw scores on 2 sub-tests, Arithmetic, and Number Series, A.C.E. Numerical. The arithmetic section consists of twenty questions, mostly on rates with some on

proportion, and no new principle past Grade XII mathematics is involved. The twenty number series questions ask for the eighth number in a series. (27)

#2. American Council on Education, PSYCHOLOGICAL EXAMINATION, 1947 Edition for College Freshmen, Linguistic Score L, consists of raw scores on the two sub-tests Same-Opposite and Completion, <u>A.C.E. Verbal</u>. The Same-Opposite and the Completion items are a measure of the extent of the students' vocabulary. The complete examination (Q and L) requires about 35 minutes actual testing time (27).

#3. <u>A.C.E. Total Score</u> is variable #1 plus variable #2.

#4. <u>IOWA SILENT READING TEST</u> New Edition, Advanced Test: Form Am (Revised). This is a fairly difficult (45-minute) test on reading comprehension with 7 sub-tests. The test is specifically constructed to test a particular study skill. (35).

#5. Iowa Placement Examinations, New Series, revised, <u>ENGLISH TRAINING</u> Series ET-2, Form M. The scores used were raw scores from this three-part test, which requires 45 minutes of testing time. The sub-tests are spelling, punctuation and language usage. (18).

#6. The absolute <u>number of supplement examinations</u> written in Grade XII, obtained from the official transcripts kept in the files. This was the only measure of this special type that was available, and so it was used.

Variables Available from Records in the Registrar's Office.

DESCRIPTION OF HIGH SCHOOL COURSES:

Flexibility of course content has been allowed in Grade X and XI courses, in order to make the most of school facilities. The teacher was encouraged to use his own discretion in programming. Practical applications were usually stressed. In Grade XII, since departmental examinations were written, the course became slightly more rigid, but this depended upon the instructor and his capabilities.

Integration of courses has been stressed. courses were developed broadly enough for the "ideal" teacher, who would then have been able to draw up his own curriculum. Practical experience was attempted to be integrated into the theory by means of activity programmes. The instructor was more or less on his own as to course content and he was also allowed this leniency in his allocation of marks in Grade X and XI. However, a uniform set of departmental examinations was made up for Grade XII and for Grade IX students, and these examinations were marked by independent examiners in Edmonton. Scores on each test were obtained by a method in which a certain percentage of the group must score within a given range of marks.

Grade XII Courses

#7. ALGEBRA 2 (5 credits)

Ratio and proportion, variation. Functions of one variable. Limits and gradients. Differentiation. Integration. Sequences and series. Permutations and combinations. The binomiol theorem. Empirical formulae.

#8. BIOLOGY 2 or SCIENCE 32 (5 credits)

A background course on the principles of Biology. Laboratory work with microscope. Dissection, magnifying glass, instruments. A survey of living things. Conservation of life. Green plants and food, metabolism. Conquest of disease. The behaviour of living things. Reproduction of living things. Variation and heredity. The kinds of living things, phyla, classes. (7) (41)

#9. CHEMISTRY 30 (5 credits)

Review of the fundamental mathematics for chemistry. Laboratory experiments and classroom demonstrations in elementary chemistry. Industrial chemistry.(41)(1)

#10. ENGLISH 30 (5 credits)

A course in language and literature. Integration of English appreciation along with creative writing is stressed. Practice in oral and written expression. Questions on literary selections. Reading appreciation and discussion. Principles of writing and composition. (3)

#11. FRENCH 30 (5 credits)

A continuation of French 20. Grammar. Nouns.

Tenses. The partitive. Pronouns. Adjectives, adverbs, possessives and demonstratives. Numbers (5)

#12. LATIN 30 (5 credits)

A continuation of Latin 20. The cases and declensions. Adjectives. Conjugation. Tense forms, infinitives, clauses, prepositions, pronouns. Conjunctions. Cardinal numbers. The subjunctive (5)

#13. MATHEMATICS 30 (5 credits)

Logarithms, trigonometric functions, solutions of the right triangle. (This part was from the Trignometry and Analytical Geometry course) Functions, the linear function and application, quadratic equations, polynomials and algebraic equations. Series of numbers, the progressions. Permutations and combinations. The binomial theorem. (This part was similar to the Algebra 2 course, excepting for the calculus) (6)

#14. PHYSICS 30 (5 credits)

Mechanics, heat and electricity. Force and motion. Work, power, energy. Machines. Heat. Magnetism and electrostatics. Radio and radiation. (1) (41)

#15. SOCIAL STUDIES 30 (5 credits)

Canada and the modern world, 1914 to the present day. The role of geography in the development of Canadian civilization. Canada and international trade. The search for security in the twentieth century. Nationalism and the modern world. The

Canadian citizen and his governments. A memory course. Some elementary economic problems, and how other people solved them. (8)

#16. <u>TRIGONOMETRY AND ANALYTICAL GEOMETRY (5 credits)</u>

Elements of trigonometry. The right triangle. The trigonometric identities. The oblique triangle.

<u>Grade XI Courses.</u>

#17. <u>ART 10 (4 or 5 credits)</u>

Watercolors, sketching. Elementary history of art. Basic principles. Color.

#18. <u>BIOLOGY I or SCIENCE II (3 credits)</u>

A general information course, not a prerequisite for future courses. Study of insects and bird life in the school community. A scientific foundation for health habits.

Interdependence of life. Nutrition, protection, reproduction. Food, water, oxygen and temperature and life. Cycles of life matter and energy. The balance of nature. Field trips. Green plants and energy transformations. Basic structure of plants. Cells and function. Food and metabolism. Microorganisms. Conservation of life. (7) (41).

#19. <u>BOOKKEEPING 10 (2 or 3 credits)</u>

An exploratory course in Bookkeeping. Proprietorship records. Business terms. Neatness. Trial balance. Financial statements. (2).

#20. <u>CHEMISTRY I (5 credits)</u>

Experiments in change in weight of metal when

heated. Decomposition of a compound. Oxygen, preparation and properties. Hydrogen, preparation and properties. Electrolysis of water. Chlorine, preparation and properties. Hydrochloric acid and test for a chloride. Forms of sulfur, hydrogen sulfide. Sulfur dioxide and sulfurous acid. Carbon dioxide, preparation and properties. Treatment of hard water. Carbon monoxide, preparation and properties. Ammonia, preparation and properties. Nitric acid. (41)

#21. ELECTRICITY 10 (4 or 5 credits)

A first course in theory of electricity.

#22. ENGLISH LANGUAGE 20 (5 credits)

Preparing reports. Learning to write expository articles. Increasing your vocabulary. Reading newspapers intelligently. Writing for the school newspaper. Learning to speak and listen. The radio. The motion picture. Cultivation of critical thinking. Business English. Magazines and periodicals. Fundamentals of writing. Grammar and composition. (3).

#23. ENGLISH LANGUAGE 21 (5 credits)

Journalism. Short story writing. Play writing and radio script writing. Essay writing. Verse writing.

#24. ENGLISH LITERATURE 21 (5 credits)

A survey course of English literature. Major writers and their work. Adventure into: The medieval period. The Elizabethan Age. The seventeenth century. The eighteenth century. The Victorian

age. The modern age.

A reading course in the history of English literature Predominantly a fine arts course. (76)

#25. <u>FARM AND HOME MECHANICS 10 (5 credits)</u>

A general shop course. Up to instructor as to content.

#26. <u>FRENCH 20 (5 credits)</u>

A first course in French vocabulary. The spoken language. Talking in French. Writing. (5)

$27. <u>HEALTH AND PHYSICAL EDUCATION (3 credits)</u>

A theory and a physical education course.

#28. <u>LATIN 20 (5 credits)</u>

A first course in Latin. Vocabulary. Reading. (5)

#29. <u>LAW 20 (3 credits)</u>

A general information course in law. Principles of commercial law. Individual rights. Function and purpose of law. Legal procedure and common law. Cases. (2).

#30. <u>MATHEMATICS 20 (5 credits)</u>

Algebra, ratios used in trigonometry. Geometry, locus and the circle. (6)

#31. <u>MATHEMATICS 22 (5 credits)</u>

Review of fundamental operations, addition, subtraction, multiplication, division; factoring highest common factor, least common multiple, cancellation, vulgar, decimal and percentage

fractions; ratio and proportion, direct, inverse and compound; powers and roots of squares and cubes. Review of rise of symbols, arithmetic and algebraic, addition, subtraction, multiplication, division and brackets; positive and negative quantities; fundamental operations in algebra. Logarithms using tables. Review of simple factoring (common factor, factor by grouping, differences of squares). Review of simultaneous equations of the first degree, simple examples and problems. Factoring a trinomial. Quadratic equations. Lines, circle, radius, diameter, circumference, arc. Areas, circle, surface of spheres, cylinders, prisms, frustra of cones and pyramids. Volumes, spheres, cylinders, prisms, frustra of cones and pyramids. Powers and roots, positive, negative and fractional exponents, zero exponents, roots mostly rational. Trigonometry. Angles, positive and negative, systems of measurement. Trigonometric functions, definitions, values from figures and tables. Solution of right triangles. Problems dealing with heights and distances, angles of elevation and depression. Graphs. Graphs of first degree functions. Graphs of second degree functions related to formulas. Graphs of simple trigonometric functions. (6).

#32. MUSIC 10 (3, 4 or 5 credits)

Vocal work, Musical instruments. Scales. Music appreciation.

#33. <u>OFFICE PRACTICE 20 (5 credits)</u>

Practice and development of skills for initial employment in an office. Personality development. Office organization. The receptionist. Business practice. Filing. Employment. Machines. Similar to Clerical Practice 20. Seldom offered (2).

#34. <u>PHYSICS 1 (5 credits)</u>

Matter and mechanics. Molecular physics. Heat sound and light.

Experiments in liquid pressure, Archimedes' principle, specific gravity of solids. Specific gravity of liquids. Weight of air. Boyle's Law. Fixed points on a thermometer. Expansion of solids. Expansion of liquids. Convection in liquids. Velocity of sound in air (resonance method) Measurements of candle power of different sources of light (photometer method.) (41)

#35. <u>PSYCHOLOGY 1 (3 credits)</u>

An exploratory course in psychology. From the viewpoint of idealistic philosophy towards life. Wants. Habits. Science. Study. Attitudes. Attention. Memory. Learning. Fatigue. Feelings and emotions. Thinking. Propaganda. Heredity. Conflict. Vocations. Character. Adjustment. Personality. Delinquency. Mental health (8).

#36. <u>SOCIAL STUDIES 20 (5 credits)</u>

Modern background of civilization. The expansion of habitable and productive areas since the beginning

of the modern age. The effect of science on our economic life. The rise of nationalism; the expansion of European empires. The development of parliamentary government in Britain and in Canada; a comparison with the constitution of the United States of America. Social enlightenment and reform. The background of Canadian cultural and religious development. (8)

#37. SOCIOLOGY I (3 or 4 credits)

The structure of modern society and the social problems left by the war. The Alberta scene. Practical examples of sociology. Social change. Internationalism. Democracy. Crime and punishment. Classes. Poverty. Social thinking. The mob mind. Propaganda. Statistics. Barbaric survivals. Social progress. (8).

#38. TYPEWRITING 10 (3 or 5 credits.)

An exploratory course in typewriting. Closely supervised practice in typing. Techniques. Business letters. (2)

#39. WOODWORKING 10. (4 or 5 credits.)

A Shop course in woodworking.

Special Variables also Available from Records in the Registrar's Office.

#40. THE NUMBER OF YEARS SPENT IN HIGH SCHOOL

It was hypothesized that students spending two or three years in Grade XII were not academically predisposed, and so this measure was added to the list

of predictors.

#41. THE NUMBER OF YEARS SPENT OUT OF HIGH SCHOOL before coming to university. There have been mixed feelings regarding the student who has industrial experience before continuing his studies. A test of the effect of this experience was therefore made, using the years out of school as a measure of this experience.

#42. AVERAGE GRADE XII MARKS were available directly from the cards. It was thought that this average might be a reliable measure of the student's potential ability. Furthermore, this was the means used in actual selection of students, and a check on the predictive value of Grade XII average marks was therefore sought.

#43. AVERAGE GRADE XI MARKS were obtained by assigning a value of 5.0 for H standing, 4.0 for A, 3.0 for B, 2.0 for C, and 1.0 for D. These assigned values were then averaged for the various subjects taken. Unfortunately some of the Grade XI marks were put into the Grade X column of the cards from the Registrar's Office, so that the average represented more the compulsory subjects than the electives, which were the most often included in the Grade X column. Nevertheless, the average of these marks should have been of some predictive value, and it was the attempt of this study to evaluate the extent of this predictive value.

#44. MATHEMATICS-SCIENCE AVERAGE.

The average of Mathematics 30, Physics 30, and Chemistry 30 marks was also used as a variable in this study to see if prediction by these three courses combined was not better than the prediction by Grade XII average marks alone. Where Trigonometry and Analytical Geometry marks were available, they were also included in this average. An average rather than a weighted score was used because the departmental examinations changed from year to year.

#45. DIFFERENCE BETWEEN VARIABLES #44 and VARIABLE #42.

The difference between Grade XII average marks (times three), and the total of Mathematics 30, Chemistry 30, and Physics 30 marks was used as a predictor variable in order to ascertain whether the ability to make generally high marks was more important than the trend toward higher marks in the sciences and mathematics. It was thought that the trend in student's marks might also be a reflection of interests, and so prove important as an extra gauge of the probability of success in an engineering course. Variable #45 was simply the difference between variable #44 and variable #42.

THE CRITERION

There were several excellent measures available as criterion for this study. The first year committee, for example, had divided the students into various categories

on the basis of their marks and other considerations. It would therefore have been possible to compute biserial correlations using the failing group and the passing group for so doing.

It was also possible that marks could have been obtained after the student had completed several years of study, or even after he had graduated and achieved some measure of success. The complications of maintaining records for such a study are obvious, and this approach was discarded despite its merits.

Since the first year average mark formed a basis for some of the decisions of the first year committee, and because they have been shown to have excellent predictive value of marks obtained in the later years at university, it was thought that here was a criterion that would be a reasonably fair indication of a student's likely prowess as an engineer.

Then too, there was the administrative view that with increasing numbers of students enrolling, it was likely that selection of students most likely to get through their first year at university would be most important in order to even accomodate the more desirable student.

In face of the above considerations, and because the average would probably be most accurate since it represented scores in several subjects, <u>average first year marks</u> were used in the present study as the <u>criterion.</u>

The following were the first year courses taken by all engineering students:

Mathematics II: 3 hrs. lect., 2 hrs. lab.
Plane Trigonometry: Solution of triangles. Trigonometric identities and equations. Elements of spherical trigonometry. Binomial theorem. Approximation. Rates of change. Differentiation of simple functions. Analytical geometry of the straight line, circle and conic sections.

Engineering Mechanics I 3 hrs. lect.
Fundamental principles of statics, centres of gravity, moments of inertia, analytical and graphical solutions applied to determination of stresses in simple frames.

Drawing IV 2 hrs. lect. 3 hrs. lab.
Orthographic projection of points, lines, plane figures, curved surfaces and solids on any image plane, true views by projection and by revolution, engineering problems dealing with points, lines, planes, curved surfaces and solids in space.

Drawing II 3 hrs.
Freehand drawing, freehand single-stroke lettering, use of drafting instruments, geometric drawing, orthographic views, pictorial drawing, conventions, dimensions, simple detail and assembly drawings, tracings and blue printing.

Civil Engineering 5 2 hours, second term, also every day during 4 weeks field work
The theory and practice of plane and topographic surveying, including construction, use and care of instruments; computation of areas, methods of topographic surveying; route surveys, including curve and earthwork problems; mine surveys; land-survey system.

Civil Engineering 6 4 weeks at end of second term.
Field work, including chaining, rodding, levelling, transit work, plotting of field notes.

Chemistry 40 3 hrs. lect. 3 hrs. lab.
Lectures: The principles of inorganic and analytical chemistry.
Chemistry of the metals and their compounds.
Laboratory: Qualitative inorganic analysis.

Physics 21 3 hrs. lect. 2 hrs. lab.
Properties of matter, heat and sound, illustrated by experiments.

IV
THE METHOD

The preliminary experimental group were those individuals who wrote examinations in first year engineering in April of 1954. In order to simplify the initial calculations for this project, certain individuals were eliminated from this group.

A list containing the results for first year students on variables #3 and #4 was available through the Student Advisory Services. This list was reproduced by means of ozalid prints, and variables #1, #2 and #5 were added to these reproductions from the information contained in the individual files maintained by the Student Advisory Services. The total number of first year engineering students for whom there was some information on one of the five variables was 281.

A separate set of records was also made available through the Registrar's Office. These records were on $8\frac{1}{2}$" x $5\frac{1}{4}$" manilla cards, and were grouped in that office according to the year the student had cleared, and also according to the faculty to which the student belonged. These cards were photostated and reduced to one-quarter size, with 30 cards to a photostat. The photostat sheets were then cut up and reclassified.

In all, 333 students wrote first year applied science examinations in April of 1954. Only 270 of these were first year students; the other 68

were students from past years who had not yet obtained first year clearance.

(Group A) The results of these above 68 were discarded from the sample in an attempt to simplify the project.

(Group B) In matching the records of the first year students kept by the Student Advisory Services and by the Registrar's Office, it was found that of the 281 for whom records were available at the Student Advisory Services, 19 did not write first year final examinations in Engineering, and so no records of them were available in the Registrar's Office. It was assumed that these people either transferred to other faculties or dropped out of university.

(Group C) Included 3 who transferred during the year from other universities and so did not have records in the Student Advisory Services.

(Group D) Included 5 for whom no records were available in the Student Advisory Services.

There were thus 270 students for whom fairly complete data were available.

It was thought that further reduction of this group was necessary in order to make the group more homogeneous. This procedure would greatly simplify interpretation of correlations, and might reduce variability enough to allow very high prediction. Those excluded from the initial sample of 270 were:

(Group E) 17 who had taken all of their high school training outside of Alberta. For 3 of these, there was also no record of their American Council on Education (Q and L) English Training or Iowa Silent Reading results.

(Group F) 12 who had taken some high school outside of Alberta.

(Group G) 5 for whom no Grade X or Grade XI marks were given on their card, and for whom no transcripts of marks were available. For 4 of these, there was also no record of how long they had spent between leaving school and coming to the university.

(Group H) 2 who wrote Grade XII finals as adults, without having taken the courses.

It was thought that the number of extraneous variables would be cut to a minimum in this way. However, there now existed another problem resultant from clerical omissions. There were cards with data missing for some of the predictors that might later prove important. Since a multiple correlation technique was being used, those individual records with certain important information missing were dropped from the sample, as follows:

(Group I) 1 for whom there is no record of the American Council on Education sub-scores Q and L.

(Group J) 2 for whom there is no record of English Training scores.

(Group K) 5 for whom there is no record of the

number of Grade XII supplemental examinations written. Of these, 2 have no record of American Council on Education (Q and L), English Training or Iowa Silent Reading scores.

(Group L) 4 for whom there is no record of the number of years spent in high school

This procedure eliminated a total of 48 from the group, leaving 222 subjects.

Upon further investigation of the sample, it was found that 71 had taken trigonometry in Grade XII. Of these 71:

1 had not taken #7 Algebra 2, and
5 had failed #16 Trigonometry, but
had passed #7 Algebra 2.

(Group M) These latter 6 were separated from the sample of 71.

(Group N) This left 65 students who had taken both Algebra and Trigonometry in high school.

(Group O) Finally (222-71) or 151 had taken Mathematics 30 only represented the final experimental group. The group had thus shrunk to about two-thirds of their original number.

At this point, it was felt that further rejection of individuals from the group on the basis that they lacked scores on one of the pnobable major predictors should be stopped. It was likely that the number would be reduced too much if it were nedessary to keep them homogeneous for such subjects as Grade XII French, Latin and Biology. For a preliminary investigation such as the present one, it was thought that the further

sacrifice in numbers would be too great. If it appeared that the choice of these apparently irrelevant subjects was of major importance in first year engineering success, this effect could be studied by future investigators; perhaps an indication of the effect would be given in this study.

The group then was reduced as much as was felt practical, and even though there was a tremendous variety in the type of pre-matriculation courses chosen, these various choices would probably have had little effect on later performance. This would be proven, in part, in evaluating the significance of the difference ("t") in the mean average first year marks of the respective groups and the means of those who did not take the course.

Also, in order to see whether there had been any change in the nature of the group in eliminating various groups from this study, a calculation was made of the significance of the differences in the final performance in first year university for the various groups in comparison to the experimental group.

A review of the classifications made of the above experimental groups has been presented here, since references have frequently been made to these groups.

(Group 0) This was the major experimental group, purified of all extraneous variables. It included only those individuals for whom all test results and

and marks were available. None of the individuals herein has taken #16 trigonometry, but seven had finished their high school prior to 1953-1954. All had taken their entire high school in Alberta. The total number in this group was 151.

<u>(GROUPS #E - M)</u> These groups were a diverse sample, in which about one third had various marks missing because of clerical ommissions, and the other two thirds had an unusual high school background. Of this latter two-thirds, 17 took Grade XII in other provinces, 12 took some high school outside Alberta, and 2 wrote examinations as adults without having taken the courses. Curiously enough, the records of the one-third who had some records missing on their cards were very heavily loaded with students from city schools, who subsequently gained a very poor first year average in engineering.

<u>(Group N)</u> This group included only those individuals who had taken both #7 algebra and #16 trigonometry. About one-half had taken two years of Grade XII, eleven had graduated from school two or more years previously, and the remainder, or 20, had taken Grade XII in 1950-1953 in the regular three years.

<u>CONTROL GROUP</u> These were the total number of individuals who had taken both #7 Algebra and #16 Trigonometry and Analytical Geometry during 1952-1953. They had all finished their high school in three years, and had all been out of school one year. The total

number available was 20.

MATCHED GROUP I None of these individuals had taken #16 Trigonometry and Analytical Geometry. All had taken #13 Mathematics 30. They had all finished their high school in three years, and had come directly from high school to university without missing a year.

These individuals were matched separately to each of the twenty in the control group on the basis of high school averages.

MATCHED GROUP II These individuals had the same background as those in Group I, and were also matched on the basis of #42 high school averages.

It might be added that the individuals in Group I and Group II were also matched as close as possible to the Control Group on #3 A.C.E. Total Scores, on #5 English Training scores, and on whether there had been a rural or an urban high school background.

The main matching was on the basis of average Grade XII marks, it was not so easy to consistly match individuals on several measures at once. On the other hand Group I and II taken as a whole had exactly the same mean A.C.E., Total Scores, English Training scores and proportion of students with rural, urban, or rural-urban high school background.

RESULTS

The results in this study closely parallel those of other investigators. This serves as a further check on the validity of currently accepted ideas regarding the prediction of success in first year engineering.

The date for the major experimental group, Group O, has been summarized in Table I. All the correlations involving the full number of 151 students were significant at the 1% level, with the exception of #2 A.C.E. Verbal, #4 Iowa Silent Reading Test, #10 English 30, #40 years in high school, and #41 years out of high school. Some of these correlations with first year marks were so low as to discourage the use of the predictor concerned in the later calculations with the other groups.

A rather high correlation of 0.71 existed between the #44 average of Grade XII Mathematics, Physics and Chemistry marks. Indeed #13 Mathematics, #14 Physics, or #9 Chemistry individually show as high a correlation as #42 Average Grade XII marks for this group.

It was unfortunate that more records of Grade XI courses were not available. Because of the construction of the cards kept at the Registrar's Office, there was a tendency for most of the Grade XI marks to occur in the Grade X column, and they were not used because of the uncertainty as to their applicability as a Grade XI

mark. This accounts for the small numbers shown for some of the correlations.

However, any correlation involving nearly all of Group O for the Grade XI courses was significant at the 1% level. Again the sciences, #20 Chemistry, and #30 Mathematics were superior predictors in comparison to #22 English, #26 French, and #36 Social Studies. The majority of Grade XI courses do show some relationship with the criterion. Indeed, the Grade XI average was a better predictor than any one of the psychological tests used in this study.

Because of the discouragingly small number of marks available, the use of predictors #17 to #39 inclusive involving Grade XI subjects was not carried out with the other groups.

Despite the slightly skewed nature of the Grade XII marks, the correlations for Groups E-M were not appreciably lower than those for Group O. It was not known why the correlation using Grade XI marks was so high at 0.67. All correlations were significant at the 2% level when the results of the full 38 were available excepting in the case of #3 A.C.E. total score, #10 English and #15 social studies. (see Table II)

Referring next to Table III, it will be seen that for Group N (the group including those individuals with trigonometry and calculus training, and all of whom had been away from school for at least one year) the correlations were similar to those obtained using the other groups, but they were consistently much lower.

TABLE I

PRODUCT-MOMENT CORRELATIONS OF ALL VARIABLES WITH THE CRITERION FOR THE MAJOR AND HOMOGENOUS EXPERIMENTAL GROUP, GROUP O (ALL INDIVIDUALS IN THIS GROUP HAD NOT TAKEN #16 TRIGONOMETRY AND ANALYTICAL GEOMETRY.

PREDICTOR OR INDEPENDENT VARIABLE	NUMBER AVAILABLE IN GROUP	PRODUCT-MOMENT CORRELATION WITH CRITERION	SIGNIFICANCE OF THE CORRELATION "t"	PROBABILITY THAT CORRELATION OCCURRED BY CHANCE
#1. A.C.E. NUMERICAL	151	0.399	5.32	<0.01
#2. A.C.E. VERBAL	151	0.120	1.47	0.15
#3. A.C.E. TOTAL SCORE	151	0.270	3.52	<0.01
#4. IOWA SILENT READING TEST	151	0.007	0.09	>0.50
#5. ENGLISH TRAINING	151	0.280	3.56	<0.01
#6. NO. OF SUPPLEMENTAL EXAMS.	151	-0.250	3.15	<0.01
#8. BIOLOGY 2	17	0.422	1.80	0.10
#9. CHEMISTRY 30	151	0.572	8.50	<0.01
#10. ENGLISH 30	151	0.187	2.32	0.02
#11. FRENCH 30	118	0.284	3.20	<0.01
#12. LATIN 30	30	0.397	2.30	0.03
#13. MATHEMATICS 30 (ALGEBRA)	151	0.595	9.20	<0.01
#14. PHYSICS 30	151	0.603	9.20	<0.01
#15. SOCIAL STUDIES 30	151	0.230	2.89	<0.01

TABLE I (Continued)

	PREDICTOR OR INDEPENDENT VARIABLE	NUMBER AVAILABLE IN GROUP	PRODUCT-MOMENT CORRELATION WITH CRITERION	SIGNIFICANCE OF THE CORRELATION "t"	PROBABILITY THAT CORRELATION OCCURRED CHANCE
#17.	ART 10	5	0.513	1.03	0.4
#18.	BIOLOGY 1	4	-0.577	1.00	0.6
#19.	BOOKKEEPING 10	7	-0.478	1.22	0.4
#20.	CHEMISTRY 1	128	0.392	4.78	$<$0.01
#21.	ELECTRICITY 10	6	0.662	1.76	0.2
#22.	ENGLISH LANGUAGE 20	151	0.202	2.52	0.01
#23.	ENGLISH LANGUAGE 21 (JOURNALISM)	3	-0.306	0.322	$>$0.5
#24.	ENGLISH LITERATURE	24	0.178	0.846	0.4
#25.	FARM & HOME MECHANICS 10	6.	0.440	0.978	0.45
#26.	FRENCH 20	120	0.286	3.22	$<$0.01
#27.	HEALTH & PHYSICAL EDUCATION	47	0.164	1.11	0.3
#28.	LATIN 20	28	0.352	1.92	0.08
#29.	LAW 20	7	-0.336	0.80	0.45
#30.	MATHEMATICS 20 (ALGEBRA)	148	0.456	6.20	$<$0.01
#31.	MATHEMATICS 22 (GEOMETRY)	11	0.366	1.18	0.3

TABLE I (Continued)

	PREDICTOR OR INDEPENDENT VARIABLE	NUMBER AVAILABLE IN GROUP	PRODUCT-MOMENT CORRELATION WITH CRITERION	SIGNIFICANCE OF THE CORRELATION "t"	PROBABILITY THAT CORRELATION OCCURRED CHANCE
#32.	MUSIC 10	7	0.673	2.04	0.10
#33.	OFFICE PRACTICE 20	3	-0.502	0.578	>0.5
#34.	PHYSICS 1	44	0.260	1.75	0.10
#35.	PSYCHOLOGY 1	37	0.151	0.895	0.4
#36.	SOCIAL STUDIES 20	151	0.229	2.86	0.01
#37.	SOCIOLOGY 1	16	0.497	2.14	0.05
#38.	TYPEWRITING 10	19	-0.0150	0.064	>0.5
#39.	WOODWORKING 10	3	0.327	0.346	>0.5
#40.	YEARS IN HIGH SCHOOL	151	-0.048154	0.586	0.55
#41.	YEARS OUT OF SCHOOL	151	-0.023958	0.291	>0.50
#43.	AVERAGE GRADE X1 MARKS	151	0.37873	5.27	<0.01
#42.	AVERAGE GRADE X11 MARKS	151	0.61746	9.58	<0.01
#44.	TOTAL OF MATHEMATICS, PHYSICS & CHEMISTRY	151	0.71378	12.4	<0.01
#45.	DIFFERENCE BETWEEN #43 and #42	151	0.45287	6.19	<0.01

TABLE II

PRODUCT-MOMENT CORRELATIONS OF VARIABLES WITH THE CRITERION FOR THE MISCELLANEOUS GROUPS E-M. (INDIVIDUALS IN THESE GROUPS WERE RESPONSIBLE FOR MOST OF THE EXTRANEOUS VARIABLES)

PREDICTOR OR INDEPENDENT VARIABLE	NUMBER AVAILABLE IN GROUP	PRODUCT-MOMENT CORRELATION WITH CRITERION	SIGNIFICANCE OF THE CORRELATION "t"	PROBABILITY THAT CORRELATION OCCURRED BY CHANCE
#3. A.C.E. TOTAL SCORE	47	0.148	0.985	0.30
#5. ENGLISH TRAINING	48	0.329	2.37	0.02
#8. BIOLOGY 2	3	0.747	1.11	0.50
#9. CHEMISTRY 30	38	0.562	4.08	$<$0.01
#10. ENGLISH 30	37	0.275	1.68	0.10
#11. FRENCH 30	23	0.238	1.12	0.30
#12. LATIN 30	8	0.493	1.38	0.25
#13. MATHEMATICS #30& ALGEBRA 2 #7	38	0.602	4.50	$<$0.01
#14. PHYSICS 30	38	0.491	3.37	$<$0.01
#15. SOCIAL STUDIES 30	36	0.126	0.736	0.50
#16. TRIGONOMETRY	8	0.138	0.338	$>$0.50
#43. AVERAGE GRADE XI MARKS	23	0.670	4.13	$<$0.01
#42. AVERAGE GRADE XII MARKS	38	0.592	4.38	$<$0.01
#44. MATHEMATICS-SCIENCE AVERAGE	38	0.701	5.93	$<$0.01
#45. DIFFERENCE BETWEEN #43 & 42	38	0.387	2.50	0.02

TABLE III

PRODUCT-MOMENT CORRELATIONS OF VARIABLES WITH THE CRITERION FOR GROUP N. (INDIVIDUALS IN THIS GROUP HAD TAKEN #16 TRIGONOMETRY AND ANALYTICAL GEOMETRY UNDER THE EARLIER SCHOOL SYSTEM)

	PREDICTOR OR INDEPENDENT VARIABLE	NUMBER AVAILABLE IN GROUP	PRODUCT-MOMENT CORRELATION WITH CRITERION	SIGNIFICANCE OF THE CORRELATION "t"	PROBABILITY THAT CORRELATION OCCURRED BY CHANCE
#3.	A.C.E. TOTAL SCORE	59	0.152	1.15	0.25
#5.	ENGLISH TRAINING	60	0.225	1.76	0.09
#8.	BIOLOGY 2	8	0.610	1.88	0.10
#9.	CHEMISTRY 30	64	0.393	3.31	<0.01
#10.	ENGLISH 30	64	0.180	1.45	0.20
#11.	FRENCH 30	53	0.405	3.14	<0.01
#12.	LATIN 30	6	-0.162	0.323	>0.50
#7.	ALGEBRA 2	64	0.232	1.87	0.07
#14.	PHYSICS 30	64	0.547	5.13	<0.01
#15.	SOCIAL STUDIES 30	63	-0.083	0.625	>0.50
#16.	TRIGONOMETRY	64	0.319	2.65	0.01
#42.	AVERAGE GRADE XII MARKS	64	0.449	3.93	<0.01
#43.	AVERAGE GRADE XI MARKS	63	0.256	2.06	0.05
#44.	MATHEMATICS-SCIENCE AVERAGE	64	0.517	4.77	<0.01
#45.	DIFFERENCE BETWEEN #43 & #42	64	0.235	1.90	0.06

Referring next to Table IV, it was found that when the whole group was used in the calculation of the validity indices of the various predictors, these indices remained consistently high. The correlation using #44 the Mathematics-Science average was 0.67 which was only slightly lower than the correlation of 0.71 obtained in the case of Group O. Indeed, this validity index is the most statistically significant of all the figures reported in this study; it has a "t" value of 14.1.

All of the correlations are significant at the 1% level. It will be noted, however, that the correlations do not always have the increased significance, despite the larger numbers, over those obtained in the case of Group O. This is true for #3 A.C.E. Toal Score and #15 Social Studies 30. Even though the marks for two different courses, #7 Algebra 2 and #13 Mathematics 30 were used interchangebly, the correlation in this case was still as significant as for Group O.

TABLE IV

PRODUCT-MOMENT CORRELATIONS OF VARIABLES WITH THE CRITERION FOR THE ENTIRE SAMPLE. (THIS SAMPLE CONSISTED OF GROUPS E-M, GROUP N AND GROUP O)

	PREDICTOR OR INDEPENDENT VARIABLES	NUMBER AVAILABLE IN GROUP	PRODUCT-MOMENT CORRELATION WITH CRITERION	SIGNIFICANCE OF THE CORRELATION "t"	PROBABILITY THAT CORRELATION OCCURRED BY CHANCE
#3.	A.C.E. TOTAL SCORE	257	0.234	3.84	<0.01
#5.	ENGLISH TRAINING	259	0.295	4.96	<0.01
#8.	BIOLOGY 2	28	0.513	3.07	<0.01
#9.	CHEMISTRY 30	253	0.529	9.81	<0.01
#10.	ENGLISH 30	252	0.217	3.52	<0.01
#11.	FRENCH 30	194	0.322	4.72	<0.01
#12.	LATIN 30	44	0.386	2.70	0.01
#13.	MATHEMATICS 30 & ALGEBRA 2, #7	253	0.506	9.28	<0.01
#14.	PHYSICS 30	253	0.576	11.2	<0.01
#15.	SOCIAL STUDIES 30	250	0.161	2.54	0.01
#16.	TRIGONOMETRY	72	0.315	2.76	<0.01
#42.	AVERAGE GRADE XII MARKS	253	0.577	11.2	<0.01
#43.	AVERAGE GRADE XI MARKS	237	0.396	6.60	<0.01
#44.	MATHEMATICS-SCIENCE AVERAGE	253	0.667	14.1	<0.01

Referring next to Table V a curious result occurred during the calculations when it was found that those taking #12 Latin made lower marks in first year engineering than those who had not taken #12 Latin. It did not seem reasonable that experience in this course should influence criterion scores, and certainly experience in other courses such as #8 Biology did not effect university marks. Further investigation revealed that all of these underachieving students were from the major Alberta city high schools, namely those of Calgary, Edmonton, Lethbridge, Medicine Hat and Red Deer, since Latin was taught only in the city schools for this sample. Underperformance of city students was manifest in all three of the major experimental groups as again shown in Table V.

Individuals from Group E-M scored much lower in first year marks. Group E-M was also heavily loaded with students who had graduated from city schools. Thus the lowered marks for Group E-M, and for those taking #12 Latin (taught only in city schools) were "chance" manifestations of the same thing, namely that graduation from a city school lowers the students likelihood for success in first year university. It was of interest to note that the above tendancy is not so pronounced in those individuals who have been away from school for a period of time, as had many of the individuals from Group N, (see Table V)

It was at first thought that an abundance of students from Edmonton might conceivably include those of lesser academic calibre but this was not significantly borne out when the marks of Edmonton students were compared to the marks of students from other cities, although the Edmonton students did score slightly lower (See Table V)

When the high school marks of this controversial group of city high school graduates was compared to the again higher marks of the urban graduates there was a near significant difference in performance. A further check on the potential ability of these urban and rural groups by means of the #3 A.C.E. total score showed a similar tendency. It was found that the city group scored slightly higher on the A.C.E., and yet under-achieved at university.

Referring again to Table V, it was found that the graduating students from a major city who had performed the worst were originally from the country. An analysis of #3 A.C.E. total scores showed these students to be drastically lowered in their average score. To a lesser but significant degree, their high school marks were also lowered.

TABLE V

COMPARISON OF SCORES ON

SOME PREDICTORS AND ON THE CRITERION

FOR RURAL AND FOR URBAN STUDENTS

***

Symbols used in this Table:

"t" is the significance of the difference between the means of the two groups.

r (bis) is the estimated biserial coefficient of correlation for the difference of the means on the variable being tested, using the formula $r(bis) = \frac{M_x - M_{xY}}{\sigma_{xY}} \cdot \left(\frac{P_x}{z}\right)$

p is the probability that the difference in the means of the two groups occurred by chance alone.

	GROUP X INCLUDES INDIVIDUALS FROM:	GROUP Y INCLUDES INDIVIDUALS FROM:	NUMBER IN GROUP X	GROUP Y
1.	Group O who had not taken #11 Latin	Group O who had taken #11 Latin	121	30
2.	Group O who had not taken #7 Biology	Group O who had taken #7 Biology	134	17
3.	Group O	Groups E-M	151	55
4.	Group O who had not taken Grade XII in a major Alberta city	Group O who had taken Grade XII in a major Alberta city	61	90
5.	Group E-M who had not taken Grade XII in a major Alberta city.	Group E-M who had taken Grade XII in a major Alberta city	25	30
6.	Group N who had not taken Grade XII in a major Alberta city	Group N who had taken Grade XII in a major Alberta city	25	39
7.	All groups who had not taken Grade XII in a major Alberta city	All groups who had taken Grade XII in a major Alberta city	111	159
8.	All groups who had taken Grade XII in Calgary, Leth. Med.Hat or Red Deer.	All groups who had taken Grade XII in major Alberta city of Edmonton	49	41
9.	All groups who had not taken Grade XII in a major Alberta city	All groups who had taken Grade XII in a major Alberta city	97	147
10.	All groups who took Grade XII in major Alberta city	All groups who had not taken Grade XII in major Alberta city	141	64
11.	All groups who permanently reside in a city	All groups who had resided in a city for Grade XII only	113	28
12.	All groups, less those from group Y	Same as above	242	28
13.	All groups, less those from Group Y	Same as above	206	28

VARIABLE BEING TESTED	MEAN OF GROUP X	GROUP Y	"t"	r (bis)	p
First year Average Marks	60.7	56.8	2.08	0.210	0.04
First year Average Marks	60.0	59.8	0.07	0.010	>0.50
"	62.0	58.9	1.93	0.171	0.06
First year Average Marks	63.8	57.7	3.53	0.359	<0.01
First Year Average Marks	61.3	56.9	1.67	0.295	0.10
First Year Average Marks	58.4	56.0	0.81	0.147	0.40
First Year Average Marks	61.8	57.1	3.53	0.274	<0.01
First Year Average Marks	58.2	57.0	0.54	0.072	>0.50
#42 Grade XII Average Marks	69.5	67.9	1.72	0.140	0.09
#[illegible]3 A.C.E. Total Score	121.8	118.9	0.92	0.087	0.35
#3[illegible] A.C.E. Total Score	124.3	111.9	3.26	0.367	<0.01
First Year Average Marks	59.31	56.42	1.59	0.140	0.11
#42 Grade XII Average Marks	68.89	65.93	1.88	0.222	0.06

Perhaps related to the underperformance of the city students, was the higher proportion of students attending with a city versus a rural domicile, as shown in Table VI. A much lower proportion of rural students attended in first year engineering than could have been expected, in view of the relative populations involved. While 35.6% of the population in Alberta was in the cities, 60.2% of the engineering freshman class took Grade XII in the city schools. When the students who were originally from the country and who had moved into the city were counted as rural students, there was still 48.8% attending from the cities. The difference between the 48.8% who actually attended, and the 35.6% who would have been expected to attend is significant at the 0.5% level for the numbers concerned.

On the other hand, an equivalent, (or in some cases a better student), as measured by the A.C.E. Total Score, is attracted into engineering in comparison to the student of other faculties such as Arts and Science, Agriculture, Commerce, Pre-Dentistry and Education, Pharmacy and Pre-Law. (See Table VII.)

PROPORTIONS OF CITY STUDENTS ATTENDING UNIVERSITY

TABLE VI

ALBERTA POPULATION FROM 1951 CANADIAN CENSUS *

	NUMBER	% of TOTAL
Calgary	129,060	13.7
Edmonton	159,631	17.0
Lethbridge	22,947	2.4
Medicine Hat	16,364	1.7
Red Deer	7,575	0.8
Sub Total of Cities	335,577	35.6
Balance of Province	603,934	64.4
Total for the Province	939,511	100.0

*See Canada Year Book, 1955

ENGINEERING STUDENTS ATTENDING UNIVERSITY 1954-5
(Corrected for rural domicile)

Domicile during High School	NUMBER	% of TOTAL
Calgary	34	13.9
Edmonton	51	20.9
Lethbridge	23	9.4
Medicine Hat	3	1.3
Red Deer	8	3.3
Sub Total of Cities	118	48.8
Other Points (including those who moved to the city from the country)	125	51.2
Total	244	100.0

ENGINEERING STUDENTS ATTENDING UNIVERSITY 1954-55
(Not corrected for rural domicile)

Took Grade XII in:	NUMBER	% of TOTAL
Calgary	60	24.5
Edmonton	37	15.2
Lethbridge	26	10.6
Medicine Hat	4	1.7
Red Deer	20	8.2
Sub Total of Cities	147	60.2
Other points (not including those who moved to the city from the country	97	39.8
Total	244	100.0

TABLE VII

SCORES OF ENGINEERING FRESHMEN GROUPS ON THE PSYCHOLOGICAL TESTS AND COMPARATIVE SCORES OF OTHER FRESHMEN ON THE PSYCHOLOGICAL EXAMINATION

VARIABLE	Mean scores for various tests given in fall of 1954: All freshmen tested (including Engineers	Engineering Group: Group O	Group N	Group E-M	Total
#3 A.C.E. Total Score	111	124	119	115	121
#4 Silent Reading	183	189			
#5 English Training	113	117	105	110	113

A.C.E. Total (Score Results for Some Freshmen Groups tested in Edmonton during the Fall of 1954 *

	NUMBER	MEAN	RANGE	STANDARD DEVIATION
Arts & Science	180	121	52-162	26.3
Agriculture	19	104	65-134	18.7
Commerce	40	121	87-157	15.1
Pre-Dentistry	23	106	87-137	15.3
Education	99	116	82-157	17.1
Pharmacy	30	109	72-157	19.9
Pre-Law	28	120	87-152	17.7
Engineering	280	120	62-172	19.3

*These data were prepared by Miss Lolita Wilson at the Department of Psychology, University of Alberta.

Of some interest was the performance of those students who had a background in #16 Trigonometry and Anolytical Geometry and #7 Algebra. One-half of this group were Grade XII repeaters, probably having taken trigonometry in their first year of high school. When a comparison was made of the trigonometry group, (including these repeaters), with Group O, who had not taken trigonometry, it was found that the trigonometry group scored significantly lower in first year university, as demonstrated in Table VIII. When the scores of the repeaters in Grade XII were not used in the comparison of the two groups, it was found that experience in trigonometry still did not enhance a student's chances of performing better in first year engineering. If any such relationship was present, it was small and inverse on the basis of the results to this point.

Indeed, upon further investigation of background, it was discovered that training outside the Alberta high schools did not seem to significantly alter later performance, except only slightly and negatively (See Table VIII)

In order to pursue more closely the reason for underachievement by students with trigonometry backgrounds, the #42 Grade XII averages and #3 A.C.E. Total Scores for Group N were compared with Group O, The students with trigonometry who indidentally had not attended university until at least one year after graduation were much lower in both potential and in past performance.

TABLE VIII

SCORES ON SOME PREDICTORS AND ON THE CRITERION FOR STUDENTS WHO HAD TAKEN HIGH SCHOOL UNDER VARIOUS SCHOOL SYSTEMS

	GROUP X INCLUDES INDIVIDUALS FROM:	GROUP Y INCLUDES INDIVIDUALS FROM:	NUMBER IN GROUPS X	NUMBER IN GROUPS Y	VARIABLE BEING TESTED	MEAN OF GROUP X	MEAN OF GROUP Y	* "t"	** r (bis)	*** p
1.	Group O	Group N	151	64	First Year Average Marks	62.0	56.9	3.09	0.278	<0.01
2.	Group O (nearly all completed high school in 1951-1954 or 3 years)	Group N who had completed high school in three years.	151	31	First Year Average Marks	62.0	60.4	0.87	0.085	0.35
3.	Group O (all took high school in Alberta.	Group E-M who did not take all high school in Alberta	151	33	First Year Average Marks	62.0	60.5	0.71	0.076	0.50
4.	Group O	Group N, who had completed high school in three years.	151	31	#42 Grade XII Average Marks	70.0	65.9	3.25	0.345	<0.01
5.	Group O	Same as above	151	27	#43 A.C.E. Total Score	123.5	116.3	1.98	0.224	0.05

* "t" is the significance of the difference between the means of the two groups on the variable being tested.

** r (bis) is the estimated biserial coefficient of corellation for the difference between the two groups on the variable being tested, using the formula $r(bis) = \frac{M_x - M_{xY}}{\sigma_{xY}} \cdot \left(\frac{P_x}{Z}\right)$

*** p, is the probability that the difference in the means of the two groups occurred by chance alone.

In an attempt to evaluate as exactly as possible the effect of previous training in trigonometry and in calculus, the matched groups were compared in performance in all the first year courses.

Referring to Table IX, experience in trigonometry and calculus seemed to have little bearing on later performance in most of the first year courses. An exception to this were the results obtained by students in Mathematics II. Both Group I and Group II (who has not taken trigonometry or calculus) obtained lower marks in this course than those from the Control Group who had a trigonometry background, with Group II scoring lower at about the 0.75% level of significance. Since there are eight courses with two indices presented for each course, the probability that an event would happen 0.75 in 100 given 16 chances to do so, is not out of reason.

Considering the results for both groups it can be said that there is no significant difference indicated in the later performance in engineering of the students trained in the high school system of 1952-1953, compared to the performance of the students trained in the high school system of 1953-1954.

COMPARISON OF THE ACHIEVEMENT IN FIRST YEAR
COURSES OF THE MATCHED GROUPS WHO HAD NOT TAKEN TRIGONOMETRY
AND CALCULUS, AND THE CONTROL GROUP, WHO HAD TAKEN THESE COURSES

CRITERION VARIABLE USED	MEAN OF CONTROL GROUP	RESULTS FOR GROUP I				RESULTS FOR GROUP II			
		MEAN	* "t"	** r (bis)	*** p	MEAN	* "t"	** r (bis)	*** p
Average first year marks	60.09	58.96	0.516	0.074	0.60	59.11	0.537	0.077	0.60
Mathematics II	64.55	61.05	0.975	0.144	0.35	53.95	2.99	0.432	<0.01
Engineering Mechanics I	57.20	53.75	1.05	0.151	0.30	56.00	0.41	0.059	0.68
Drawing II	64.95	64.55	0.278	0.040	0.75	64.85	0.056	0.008	0.95
Drawing IV	59.65	55.42	1.42	0.211	0.15	60.47	0.267	-0.039	0.80
Civil Engineering 5	58.10	55.05	0.946	0.136	0.36	55.05	1.21	0.175	0.23
Civil Engineering 6	71.20	68.70	1.11	0.160	0.28	69.85	0.767	0.110	0.45
Chemistry 40	56.60	63.53	1.40	-0.208	0.16	60.40	1.50	-0.216	0.14
Physics 21	48.95	49.00	0.01	-0.001	0.99	53.55	1.16	-0.167	0.25

* "t" is the significance of the difference between the means of the two groups on the variable being tested.

** r(bis), is the estimated biserial coefficient of corellation for the difference between the two groups on the variable being tested., using the formula $r_{(bis)} = \frac{M_x - M_{xy}}{\sigma_{xy}} \cdot \frac{P_x}{Z}$

*** p, is the probability that the difference in the means of the two groups occurred by chance alone.

In an attempt to arrive at a better predictor than the Grade XII average, separate correlations were made using #44 the mathematics-science average as a predictor, and also #45 the difference between #44 the mathematics-science average and #42 the Grade XII average. A multiple correlation of variables #45 and #42 against the criterion was 0.717 for Group O, no more than the correlation using #44 the mathematics-science average alone. This figure is probably the upper limit for prediction on the basis of school marks, because the correlation between the two variables used, #45 and #42 in the multiple correlation was merely 0.146.

It was also found that #45 difference in averages and #44 mathematics-science marks correlated 0.608 with each other, and the multiple correlation for #44 and #45 against the criterion was 0.714, again no greater than the correlation using the #44 mathematics-science average alone.

By trial and error using Table X, it was found that if an average of 50% was the criterion for passing first year university, then the minimum number of individuals would either have been wrongly selected or wrongly refused admission to the university, on the basis of both variables, if a critical score of 63% on the mathematics-science average was used. By the same method, it was also seen that in similarly increasing the entrance requirements of the Grade XII average to 63%, one does not achieve the same minimum of wrong selections

TABLE X

BIVARIATE FREQUENCY DISTRIBUTION FOR THE MATHEMATICS-SCIENCE AVERAGE AGAINST FIRST YEAR MARKS

#44 MATHEMATICS-SCIENCE AVERAGE --

FIRST YEAR AVERAGE MARKS	51-53	54-56	57-59	60-62	63-65	66-68	69-71	72-74	75-77	78-80	81-83	84-86	87-89	90-92	93-95	96-98
87-90														1		
83-86																
79-82											1	1	2	1		
75-78										3			3		1	1
71-74			1			1	1	3		8		1	1	1		
67-70					2	1	4		3	3	6	1	1	2	1	
63-66					2	5	7	11	1	2	3	1				
59-62		1	2	5	5	5	10	6	3	1	2	1				
55-58		2	1	2	5	10	6	8	2	1	1					
51-54	1	2	3	5	5	3	5	3	1	2						
47-50		2	3	3	8	8	2	1								
43-46			1	9	1	3	2									
39-42		1		4	2											
35-38			1			1										
31-34				1	1											
27-30	1															
23-26																
19-22					1											
15-18						1										

TABLE X

BIVARIATE FREQUENCY DISTRIBUTION FOR THE GRADE XII AVERAGE AGAINST FIRST YEAR MARKS

#42 AVERAGE GRADE XII MARKS

FIRST YEAR AVERAGE MARKS	51-53	54-56	57-59	60-62	63-65	66-68	69-71	72-74	75-77	78-80	81-83	84-86	87-89
87-90													1
83-86													
79-82									1	2	1	1	
75-78						1		1	1	2	1		2
71-74			1		2	1	1	3	1	5	2	1	
67-70			1	2	1	2	3	2	5	3	2	2	1
63-66				2	6	8	3	5	3	4		1	
59-62			1	8	13	5	4	6	4				
55-58			2	8	6	6	11	5					
51-54	1		2	4	8	9	3	2	1				
47-50		1	3	11	5	1	4	2					
43-46			2	8	3	2	1						
39-42				3	2	2							
35-38				1				1					
31-34				1	1								
27-30				1									
23-26													
19-22						1							
15-18					1								

as in the case of the mathematics-science average.

Using the whole group, and exercising a 65% cut-off in the mathematics-science average, the correlation of #44 the mathematics-science average with the criterion was 0.638. The relationship of these scores and also the Grade XII average with the criterion is shown in Table X.

Since there was no other highly valid predictor variable which would have a low correlation with #44 the mathematics-science marks, this average appeared to be the best single predictor of those considered in this study.

VI

DISCUSSION

At the university entrance level, the basic problem is how to train enough fully qualified engineers from the high school applicants. Here is a problem that cannot be avoided by lowering the entrance standards, because there are also standards which are set by the level of technology prevelant in our society. There is little point in graduating an incompetent technician who would not be able to plan highly complex and safe buildings, or to design machines that are necessary to our economy. In order to investigate this complex problem more fully, let us examine some of the factors that are concomitant to a successful completion of engineering courses.

The Relationship of the High School Courses:

During the design of the project, it was at one time decided to make up a group that was purified of all extraneous variables (Group O). This procedure produced some interesting results. For example, it was found that the correlations for Group O were consistently higher than those for Group N, and this latter group included only individuals who had been out of school for at least one year. There were therefore other factors affecting the university performance of these students, which were not measured directly by the variables of this study.

The lower indices may have occurred because many of these students had taken two years of high school in order to complete Grade XII. The distribution of Grade XII

averages could therefore have been skewed towards lower marks, resulting in a poorer linear relationship for all of the courses. Another possibility was that the poorer students may have been loath to attend university immediately after graduation.

However, it was unlikely that the skewed distribution of the high school marks completely accounted for the lowered correlations, for in most cases, when the results of Group N were combined with the other groups, lower correlations again resulted. In some cases the significance of the correlation was decreased, in spite of increased numbers. This could have been partly caused by the occurrence of shifting standards for the high school marks from year to year.

The most probable explanation for these low correlations for Group N would be that there were other more important factors influencing the performance of the student who has spent a year or so out of school. While these factors cannot be measured by the variables in this study, it was likely that the return to school life after some time in industry was in some cases a manifestation of an increased desire to succeed in university; such motivation has been found to sometimes outweigh academic considerations by other writers.

Despite the fact that there were many other factors operating in the prediction of success at university, it is likely that the departmental examination employed in

testing Grade XII students in Alberta is consistent enough to yield higher results that those obtainable from high school marks by universities in the United States. The problem of how these various marks should be used is discussed in a later part of this chapter.

Other considerations in the Performance of Engineering Students.

On the basis of the much lower performance of the city trained student, it is quite likely that there are social and economic factors at work in determining first year success. This underachievement may have been a sign that these individuals were potentially able to achieve, and yet did not do so because of a more active social life, or because of improper attitude. It has been felt by many educators that the city student sometimes dominated campus activities. Perhaps the city school "gang" was maintained during the first year of university. Maybe the student from the smaller community felt the onus was upon him to achieve, since if he failed, the fact would become common knowledge to a wide circle of people in the rural community, and he might have had to return to this same community if he dropped out of university.

Then too, it is not impossible that students trained under the city school system, where many specialists used "spoon-feeding" methods with the material appropriate for the successful completion of the matriculation examinations, were seriously handicapped in adapting to the less directive approach of teaching which is prevalent at

the university.

On the basis of the results of this study, there seemed a more likely explanation of these facts. Since a much higher percentage of students attended from the city than would be expected , it is not improbable that of the country students who attended, there would be a lower percentage attracted into engineering because of the glamour of the profession. Even though the country student was not of superior potential as measured by the A.C.E. Total Score, his reasons for attending in the first place were more genuine else he would not be there.

At this point, it was thought wise to avoid further speculation, especially in the face of another conundrum, that of the extremely low freshman marks obtained by the country students who had finished their high school in the city.

A possibility existed that some of these students may have been expelled from their home school, and then undertook to complete their education in a city.

Or, perhaps these individuals were sons of the more wealthy fathers, and who were able to continue schooling away from home beyond their expected achievement level. Maybe these were "professional" students, who had finally met a challenge too great for them in university training, and who found this a convenient and necessary time in which to discard parental control.

This seemed the most likely consideration, for these particular students scored much lower on the A.C.E. Total Score, and also in their Grade XII average marks. Unfortunately,the data and the number of cases was insufficient to pursue this analysis further on a scientific level.

The School System

Since it had been felt rather strongly by many in the field of education that the trigonometry and calculus courses had much to do with a student's progress in first year university, an attempt was made to evaluate as exactly as possible the importance of this controversial course.

As stated under the results, there is no reason to believe that the student schooled under the programme prior to 1953 performed better than the student in the next year under the programme in which a full course in mathematics was lacking.

It is dangerous to speculate in view of the small numbers involved, but if one were to say there was a positive tendency for higher achievement in Mathematics II by the students matriculating under the older school system, one would at the same time be forced to admit that there was a tendency of approximately the same magnitude for these same students to underachieve in Chemistry 40. While is is tempting to postulate that if the numbers had only been larger, significant differences

would have been likely in the case of Mathematics II, the overall test results indicate no basis for such presumptions.

The results of this study seemed to contradict these students of education who have charged that the weakened course content is undermining the process of training the engineer. An obvious but unprovable possibility from the results of this study was that the high school courses were so much below university level, that the increased amount of watering down during 1953-1954 was of little relative importance.

The few cases available futhermore suggest that there is little difference in the freshman marks of students who secured their matriculation outside the province of Alberta.

The Problem of Selection:

All of the above facts naturally lead to the case for improving selection. If the school system produces students who fail at a high rate at university despite the nature of courses taken, why be so formal in adopting the 60% average at the university entrance level? There are other variables proven to have a higher relationship with university performance. There is definitely a case for allowing more potential students to apply for admission, and examining them on the basis of their Mathematics-Science average, and also upon entrance tests, such as the Engineering and Physical Science Aptitude Test,

the Bennett Mechanical Comprehension Test, the Minnesota Paper Form Board, and other measures as indicated in this study, all of which might be validated for selection purposes.

In order to arrive at the cut-off in selection, the facilities and the teaching policies at the university must first be determined, and then the cut-off made on the basis of the number of students that could be handled conveniently.

If the problem,on the other hand, was how much to enlarge facilities to accomodate the influx of students, then ideally the number who were to be provided for could be determined by attempting to serve, for one year at least, all those who had shown the necessary mathematics and science academic promise at the Grade XII level. It is likely that this would be an Utopia to be aimed for, but never reached.

VII

CONCLUSIONS AND RECOMMENDATIONS

From the point of view of improved selection and counseling, several important features emerged from this study which were also in line with the results of other investigators.

1. A minimum mathematics-science average from high school deserves serious consideration as a requisite for entrance into first year engineering, instead of the present Grade XII average, the cutting score to be determined by the average enrolment and the facilities of the university.
2. Engineering students who had taken trigonometry and calculus in Grade XII did not perform better in first year university than students who had not taken trigonometry and calculus. This would indicate that there may be other potential engineering applicants who lack other courses, but who might achieve equally well at university.
3. The recent graduate from the city high school did not achieve as well as the rural student in first year university, in spite of a higher level of academic potential as measured by the American Council on Education, Psychological Examination;

This tendancy should be further investigated by means of other tests to probe the underlying social reasons.

4. Rural students who take a few years of high school in a major Alberta city achieve much below average at university. These students are also much lower in potential ability as measured by the American Council on Education, Psychological Examination. The underlying dynamics of this tendency also deserve further study.

5. On the average, the students with high academic promise as measured by the American Council on Education, Psychological Examination, were attracted into engineering, in comparison to students in other faculties. However, it is also likely that a low proportion of the highest calibre country students have been attracted into engineering. It is probable that there are many potential engineering students with rural backgrounds; an attempt should be made to promote more of these individuals into engineering.

On the basis of the findings in this study, there were several suggestions that seemed worthwhile to pass on to other investigators.

6. That a future study of this type be done using International Business Machine punchcards, or a similar card-sort method. If records were photostated, biserial correlations could profitably be employed rather than the more laborious product-moment correlation.

7. Future investigators who attempted to arrive at a best battery of tests to be used in selection might consider:

i. High school mathematics-science averages.

ii. The Engineering and Physical Science Aptitude Test.

iii. A three-dimensional space relations test similar to the Differential Aptitude Test, Space Relations, but more difficult in nature, or with a shorter time limit. Failing to find a test of this type, the Minnesota Paper Form Board would be an asset in such a battery of tests.

iv. If a college entrance examination is to be used, the Yale Scholastic Aptitude Test is probably a better predictor than the American Council on Education, Psychological Examination (23:92)

v. A test not correlating with the above tests, and measuring such things as type of school background, attitude to

school, attitude to self, and general drive in the direction of a successful engineering career would likely improve selection. Special measures should be developed for the student who comes to university after a period out of school, for the usual predictors do not show high validity in these cases. Perhaps counselling of such students through the Student Advisory Services would be of importance here.

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This study was undertaken because various facilities and test data were available. However, the results have proven worthwhile, and there is reason to believe that in a validation study carried out along the lines indicated, correlations as high as o.8 are possible. It is when test prediction reaches this figure that the fruitation of all the labours of many investigators working over a long period of time are finally realized.

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